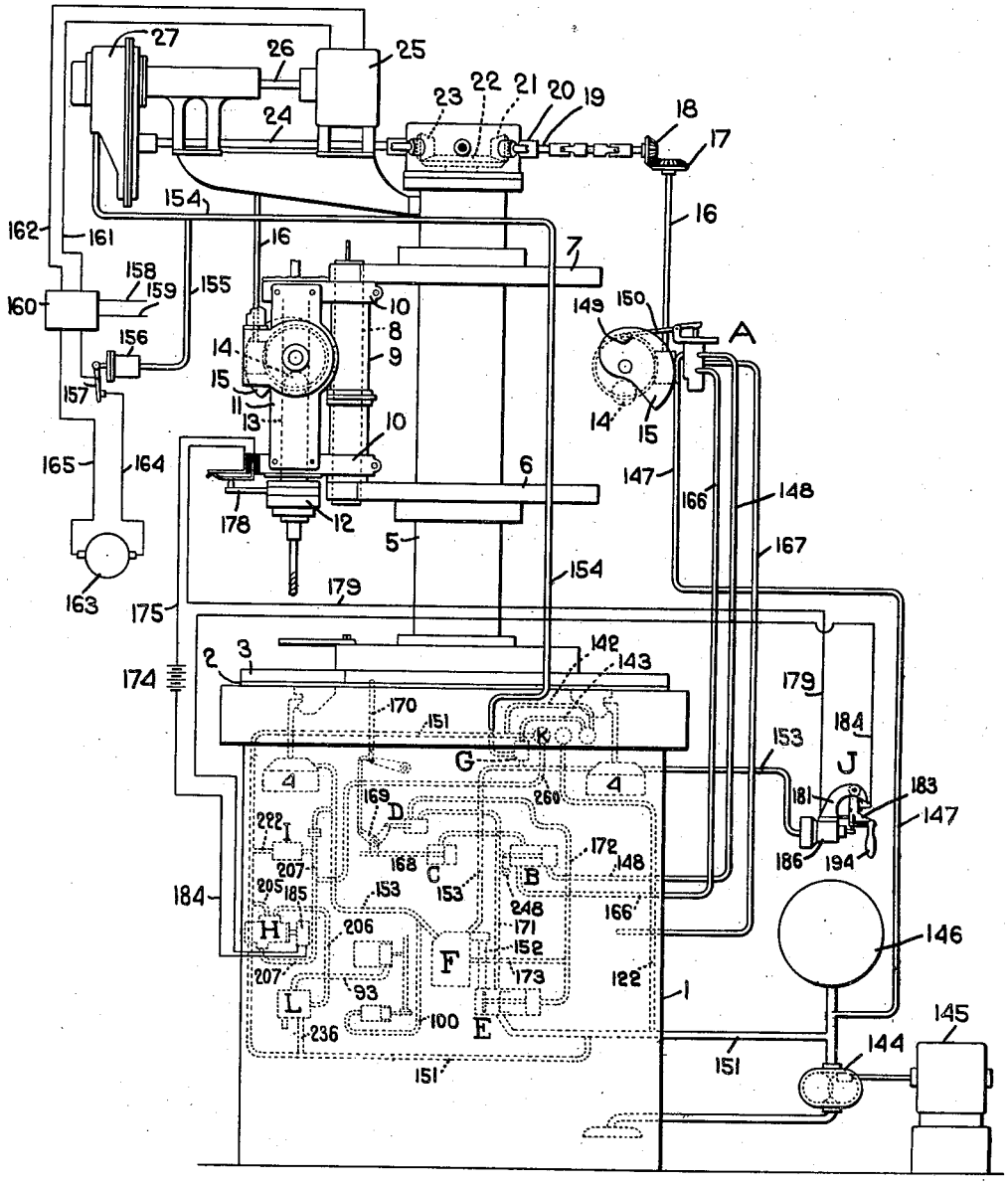
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INDEXING MECHANISM FOR AUTOMATIC DRILLING MACHINES AND THE LIKE

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Fig. 1.



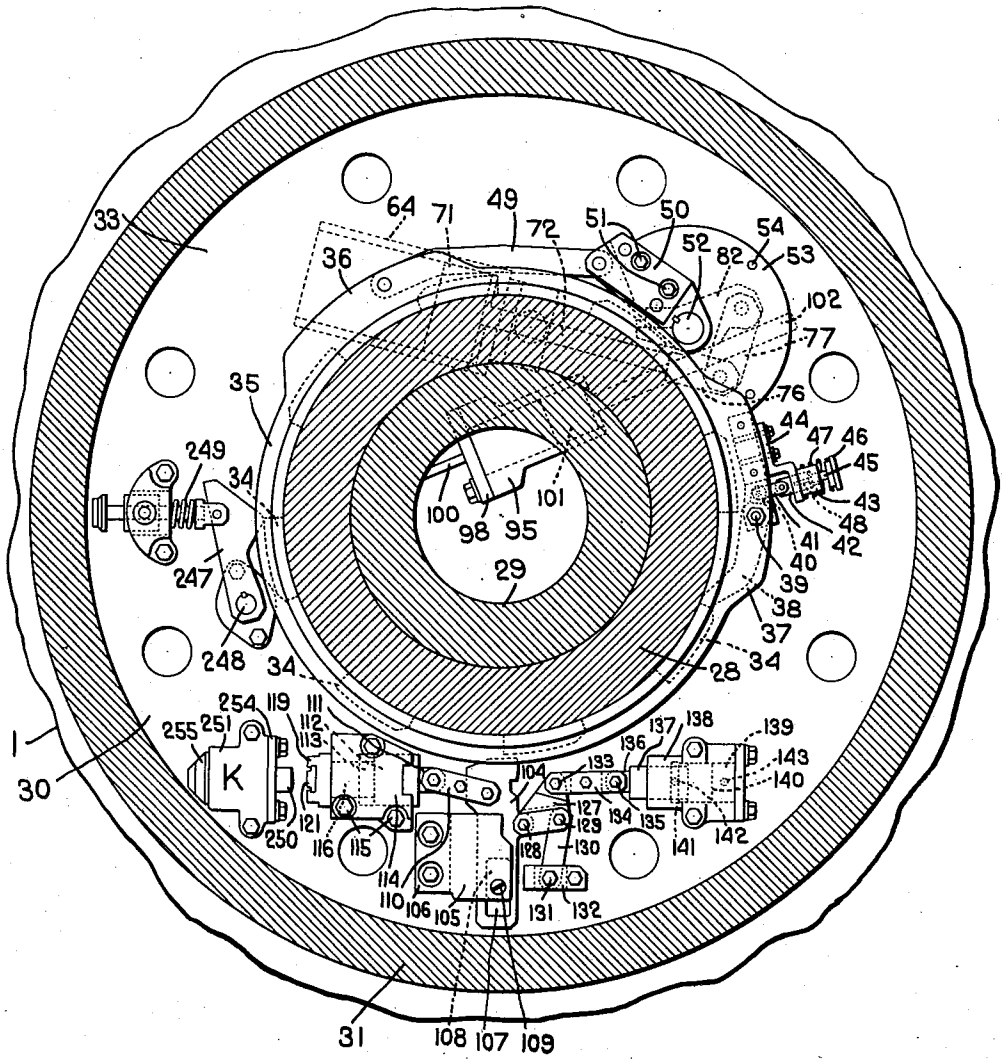
Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig. 2.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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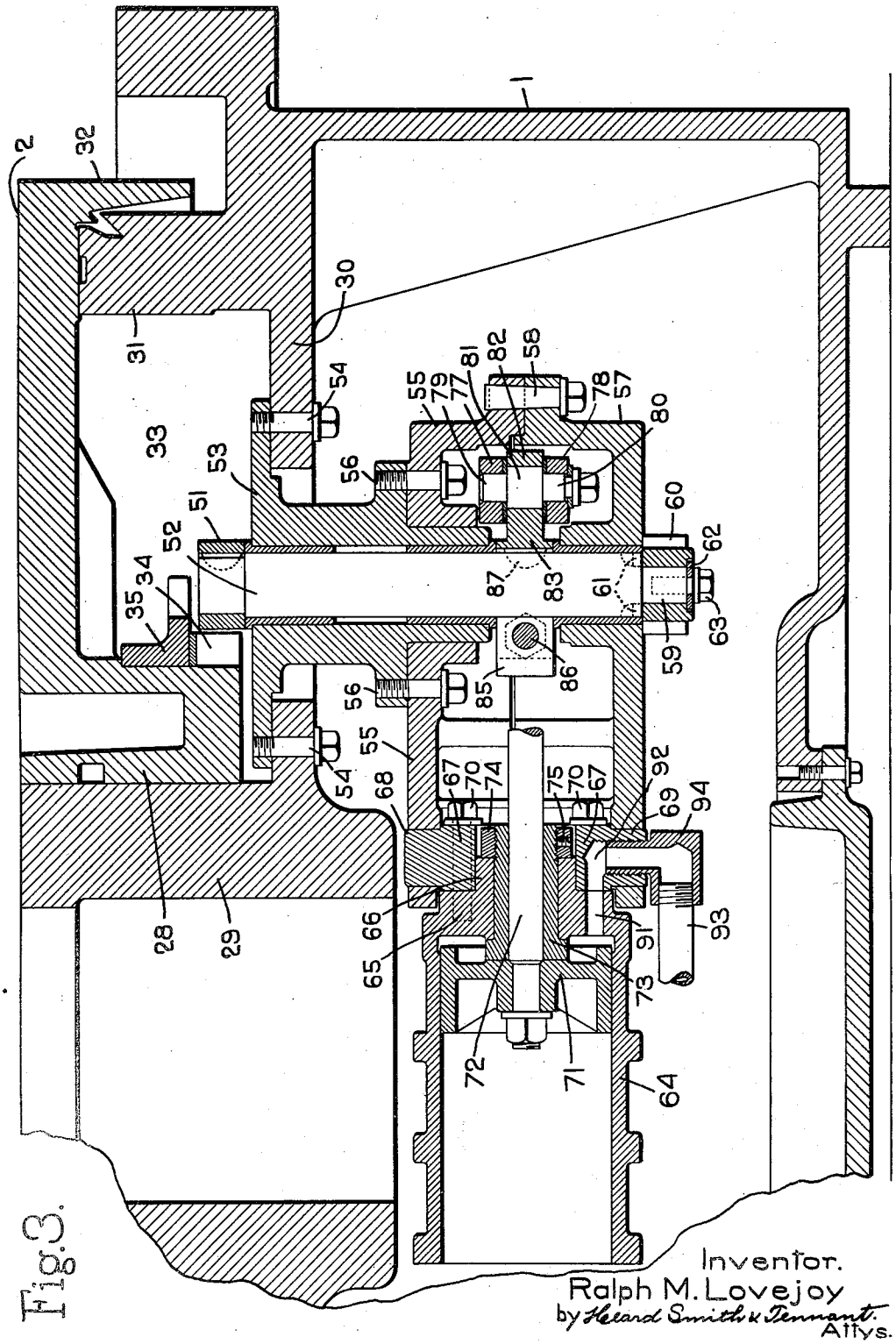


Fig. 3.

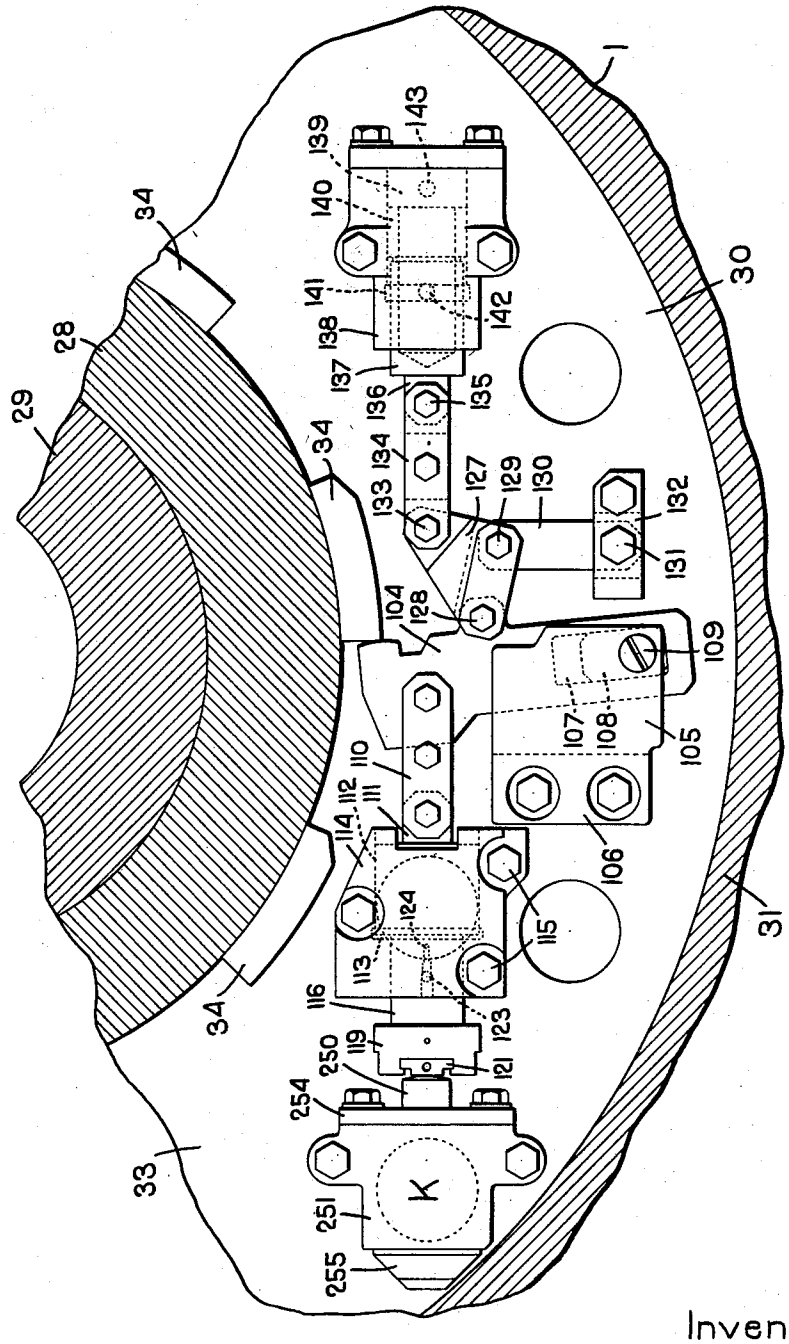
Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig. 4.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig.5.

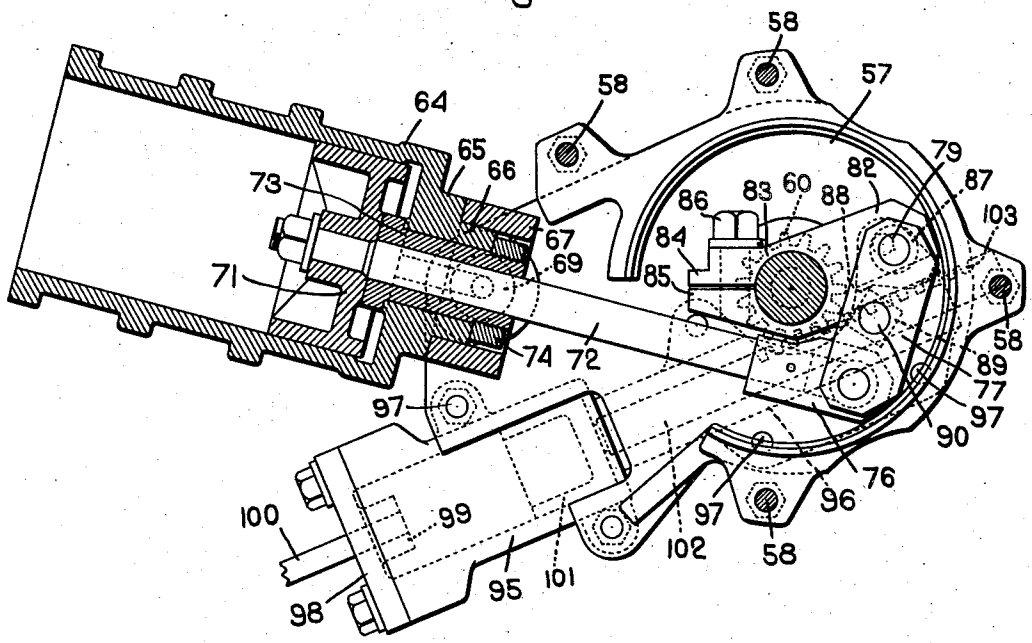
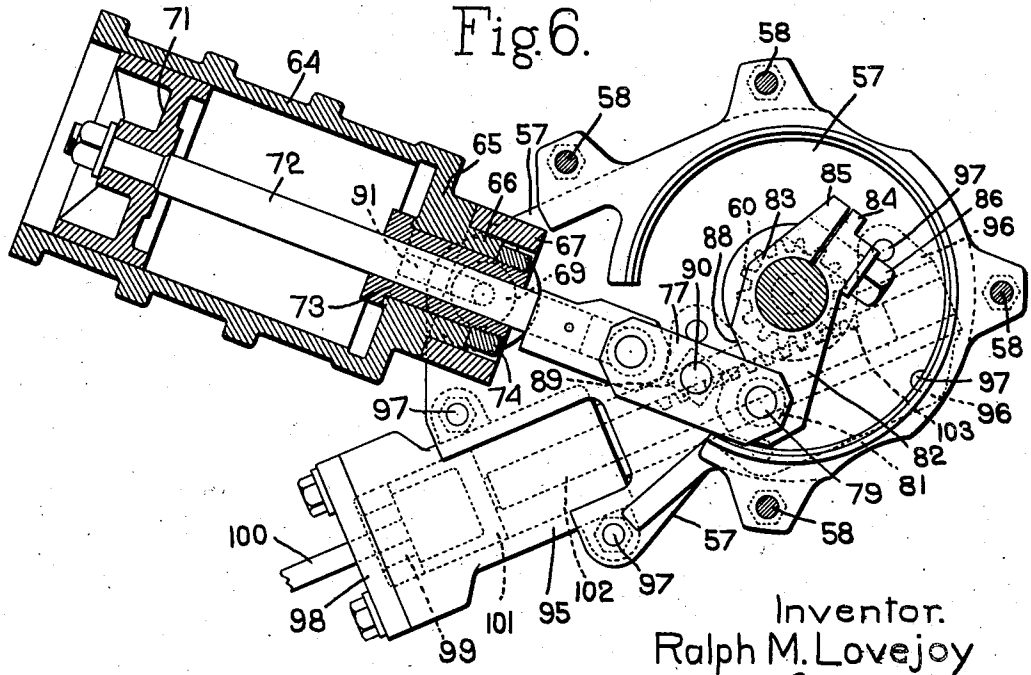


Fig.6.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig.7.

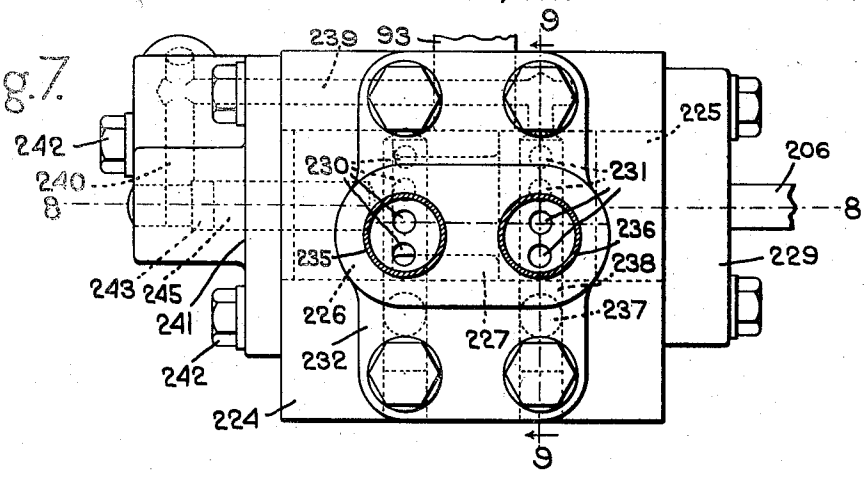


Fig.8.

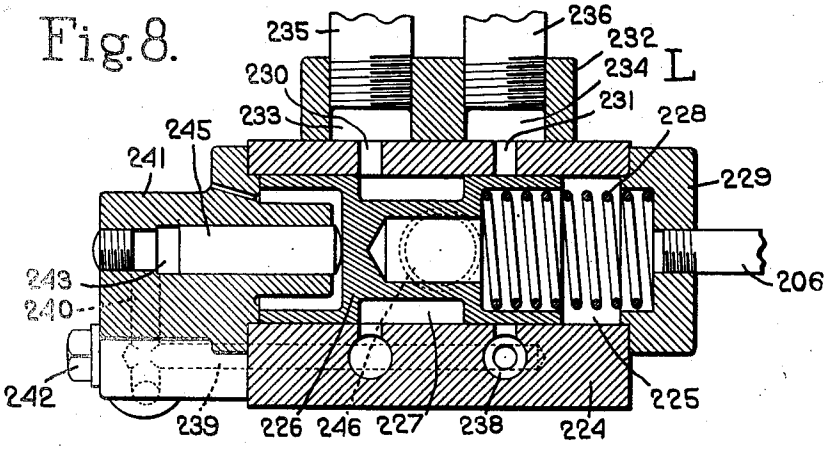
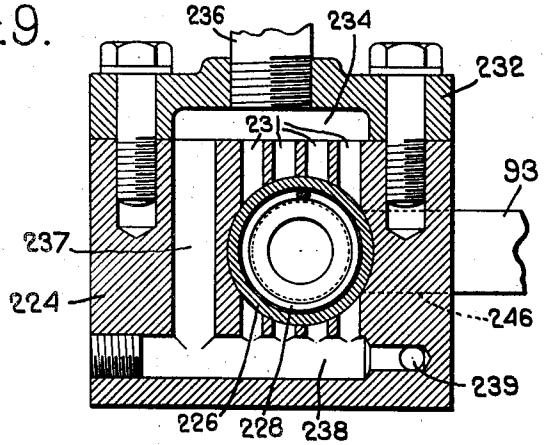


Fig.9.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig. 10.

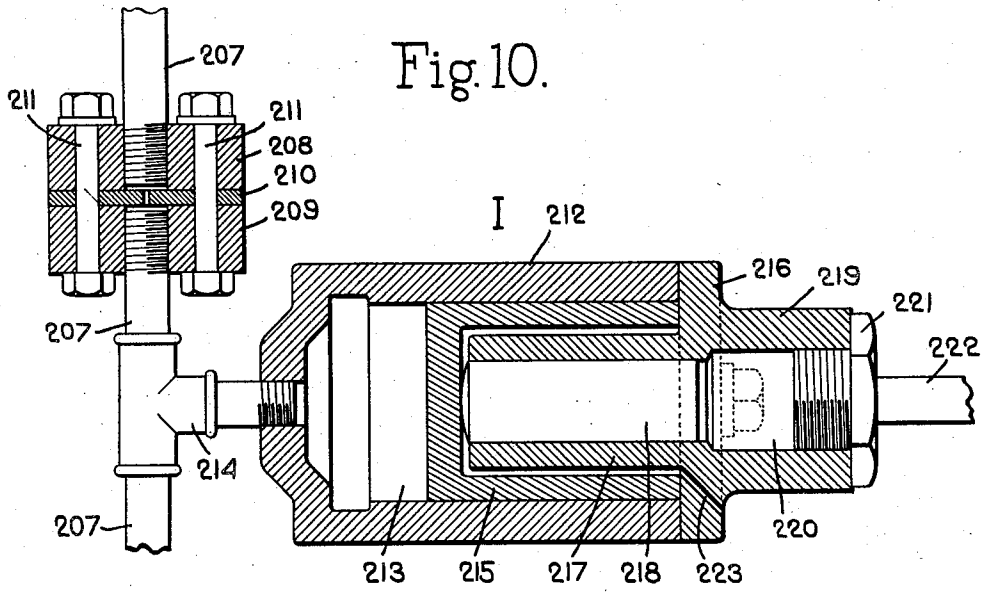
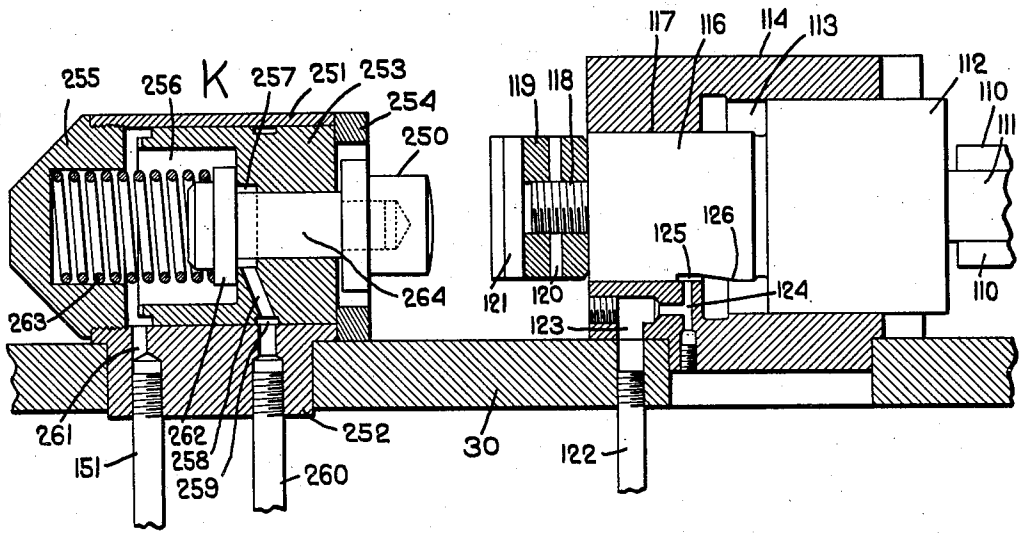


Fig. 11.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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Fig.12.

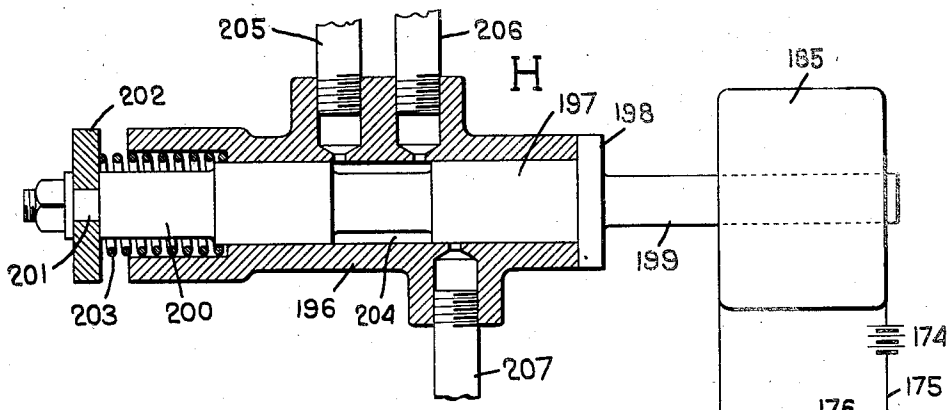
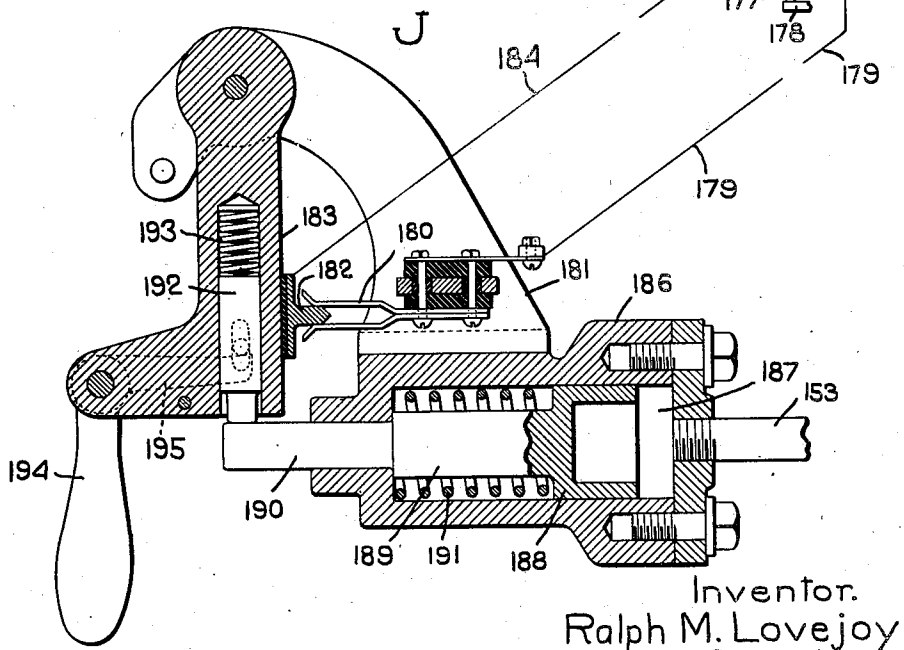


Fig.13.



Inventor.
Ralph M. Lovejoy
by Heard Smith & Tennant.
Attys.

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UNITED STATES PATENT OFFICE

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INDEXING MECHANISM FOR AUTOMATIC DRILLING MACHINES AND THE LIKE

Ralph M. Lovejoy, Boston, Mass.

Application December 26, 1930
Serial No. 504,798

19 Claims. (Cl. 29—38)

This invention relates to improvements in mechanisms for actuating and for controlling the movement of the work carrier of automatic drilling machines, and machines for other purposes, in which the work is carried by a travelling carrier successively to a plurality of stations at certain or several of which it is operated upon by a tool or tools, such as a drill, countersink, reamer, or other suitable tool.

More particularly the invention relates to improvements in drilling machines, and machines of like character, of the type disclosed in my Patent No. 1,799,594, granted April 7, 1931, for Drilling machines and machines for other purposes, and in my prior applications for patent, Serial Number 441,387, filed April 3, 1930, for Fluid operated control for multi-spindle drills; and Serial Number 471,234, filed July 28, 1930, for Fluid actuated controlling mechanism for multi-spindle drills.

The machines disclosed in these applications comprise a travelling carrier having supports for the work, means for actuating the carrier to present the work successively at a plurality of tool stations, tools at certain of said stations, means for arresting the travelling carrier with the work presented at said stations, means for locking the carrier at said stations during the operation of the tools upon the work, means for releasing the locking means to permit actuation of the travelling carrier, and means automatically operable by the means for arresting the movement of the travelling carrier to render inoperative the means for actuating the carrier, with fluid controlled means for automatically effecting and determining the sequence of operations.

In the constructions disclosed in the prior applications, the actuation of the travelling carrier is accomplished by an electric motor which drives through suitable gearing a vertical shaft extending axially through a vertical column and provided at its lower end with a suitable pinion which in turn actuates a train of gears having a pinion engaging a ring gear which is fixedly secured to the travelling carrier.

One of the objects of the present invention is to provide a simplified construction in which the travelling carrier is actuated by mechanism operable and controlled by fluid under pressure, thereby eliminating the electric motor and the power transmitting mechanism therefrom, and also providing a more powerful type of motor for actuating the travelling carrier.

Another object of the invention is to provide improved fluid-operated mechanism for arresting the travelling carrier which will more effectively insure the position of the work at the successive tool stations.

Another object of the invention is to provide effective fluid controlling mechanism for the carrier-actuating mechanism operable in conjunction with the fluid controlling mechanism for determining the sequence of operation of the travelling carrier and the drilling mechanism.

These and other objects and features of the invention will more fully appear from the following description and the accompanying drawings and will be particularly pointed out in the claims.

In the drawings:

Fig. 1 is a general view, mainly in diagrammatic form, of a multiple drill construction embodying the invention, a single drill unit being shown;

Fig. 2 is a detail view, mainly in horizontal section, of the work carrier below the upper surface thereof, illustrating the mechanism for actuating the travelling carrier and for arresting the carrier;

Fig. 3 is an enlarged vertical sectional view of a portion of the base, the rotatable carrier which is supported thereupon, and the fluid-operated mechanism for actuating the same;

Fig. 4 is an enlarged detail horizontal sectional view of a portion of the construction illustrated in Fig. 2, illustrating particularly the mechanism for arresting the travelling carrier;

Fig. 5 is a detail view, partially in vertical section, illustrating the fluid-operated mechanism for rotating the travelling carrier shown in the position in which the carrier is at rest during the operation of the drilling mechanism;

Fig. 6 is a similar detail view illustrating the position of the parts of the traveller-actuating mechanism at the end of one of the intermittent movements of the travelling carrier;

Fig. 7 is a plan view of the valve mechanism for controlling the supply of fluid under pressure to the mechanism for actuating the travelling carrier;

Fig. 8 is a longitudinal sectional view on line 8—8, Fig. 7;

Fig. 9 is a vertical sectional view on line 9—9, Fig. 7;

Fig. 10 is an enlarged view, mainly in longitudinal vertical section, of the retarding mechanism for causing a sufficient delay of the operation of the carrier-actuating mechanism to in-

sure proper locking of the carrier before the actuation of the drilling mechanism;

Fig. 11 is a vertical sectional view, on an enlarged scale of the dash pot mechanism for arresting the travelling carrier and the mechanism which is actuated upon the yielding movement of the plunger of the dash pot initially to control the operation of the carrier-actuating mechanism;

Fig. 12 is a view, partly in enlarged vertical section, of an electrically operated safety valve showing also the solenoid, a portion of the electric circuit leading thereto, and certain of the switches operable by the movement of the tools away from the work to complete the circuit; and,

Fig. 13 is a view, partially in vertical section, of the manually operable safety switch for completing the circuit of the solenoid of the electrically operated safety valve shown in Fig. 12.

Much of the construction of the present machine is identical with that disclosed in my prior applications aforesaid, particularly Serial Number 471,234 and Serial Number 441,387, and detail illustration of such identical parts is unnecessary to the disclosure of the present invention. In order, however, more clearly to identify the present invention and the disclosure with that of the prior applications aforesaid, the same letters are used herein to identify the controlling units for the fluid under pressure which may be and desirably are identical with those of previous constructions.

The construction illustrated in the accompanying drawings comprises a heavy hollow base 1, desirably of substantially cylindrical form, which provides a reservoir for oil, or other suitable fluid. A travelling carrier, in the form of a rotatable table 2, is mounted upon the base and carries a plurality of independent work-supporting members 3, preferably in the form of flat sectors which are slidably supported upon the table 2 and are movable relatively thereto both radially and circumferentially as disclosed in my prior Patent No. 1,799,594. Fluid-operated positioning means 4, carried by the base, are provided at each tool station, and are operable to position and preferably also to lock the work-supporting sectors accurately in a predetermined position at each tool station irrespective of the correct positioning of the travelling carrier. A hollow column 5, mounted upon the base 1, is provided with preferably circular, spaced apart, plates or brackets 6 and 7 which are fixedly secured to the column 1. Hollow vertical posts 8, one of which is shown, corresponding to the number of tool stations, and located at uniformly separated intervals, preferably extend through and are secured to the brackets 6 and 7 near their peripheries.

Sleeves 9, which desirably are bored eccentrically, are rotatably mounted upon these columns between the brackets 6 and 7, and provide supports for the fames of the respective tool carriers. Upper and lower brackets having semi-cylindrical sections 10 clamped upon the sleeves 9, support each tool carrying frame 11.

The tool, which may be a drill, reamer, or other device, is mounted in a chuck 12 which is connected to the end of a rotatable spindle which desirably is driven by an independent motor (not shown) and is rotatably mounted in a sliding member 13 reciprocably mounted in the tool-carrying frame 11.

The tool feeding mechanism

The sliding member 13 of each tool carrier is provided with a laterally extending roll 14 which is engaged by a tool feeding cam 15 mounted upon its frame 11. The tool feeding cam is actuated through a worm gear which is secured to the cam 15, or its shaft, and is engaged by a worm having a preferably vertical shaft 16, the upper end of which is provided with a beveled pinion 17 which meshes with a complementary pinion 18 upon a shaft 19 preferably formed in alined sections connected by a universal joint and journalled in a housing 20 mounted upon the upper end of the column 5.

The shaft 19 has upon its end within the housing 20 a beveled pinion 21 which engages a beveled gear 22 which is rotatably mounted in the housing 20. The gear 22 is engaged by a beveled pinion 23 upon a shaft 24 which is driven by an electric motor 25 through a shaft 26 and suitable gears contained within a housing 27. The housing 27 also contains fluid operated braking mechanism for quickly arresting the tool feeding mechanism when the electric circuit to the motor 25 is broken.

Any suitable means may be employed for furnishing an electric current to the motor 25 and for controlling the operation of the motor in proper sequence to the carrier-actuating mechanism such as that which will hereinafter be more fully described.

The tool feeding mechanism illustrated herein is substantially identical with that disclosed in my prior application Serial Number 471,234.

The table rotating mechanism

The work carrier illustrated herein is in the form of a rotating table 2 upon which the sector-shaped work supports above described are so mounted as to permit both radial and lateral movement. The work table 2 has an integral downwardly extending cylindrical hub 28 which is rotatably mounted upon a central boss 29 which is integral with and extends upwardly from the top 30 of the base 1 and supports the column 5.

The table 2 is supported near its periphery upon an annular boss 31 which is also integral with the top 30 of the base and extends upwardly therefrom. Desirably the table is provided with a downwardly projecting annular flange 32 which extends into a suitable annular recess in the top of the base 1, thereby preventing chips, or other foreign matter, from entering the bearing between the table and annular boss 31. It also prevents dust and other foreign matter from entering the chamber 33 within the upper portion of the base beneath the table in which the table actuating mechanism and table arresting mechanism are housed.

The lower end portion of the hub 28 is provided with a series of blocks 34 corresponding to the several tool stations and loading stations, and an actuating ring 35 is rotatably mounted upon the hub above the blocks 34 with a wear plate preferably interposed therebetween. The ring 35 is provided with two flanges 36 and 37, one of which, 36, is connected to the hydraulic actuating mechanism, and the other of which is provided with a pawl adapted to engage the blocks 34.

As illustrated herein, (see Fig. 2), a pawl 38 is located below the flange 37 and is pivotally mounted upon it by a stud 39. The pawl has a

projection 40 extending beyond the pivot and pivotally conected to a link 41, the opposite end of which link is pivotally connected to a plunger 42 which is reciprocably mounted in a dash pot 43 carried by a bracket 44 secured to the flange 37. The plunger 42 is provided with a stem 45 of relatively small diameter which extends through the otherwise closed end of the dash pot and is provided with a head 46 located at a short distance from the end of the dash pot. A spring 47 is interposed between the bracket 44 and the head 46 of the plunger. The closed end of the dash pot is provided with a small vent operative to permit a restricted flow of the liquid when the piston is forced into the dash pot by the spring 47.

The chamber 33 in the upper portion of the base is partly or wholly filled with oil, so that the dash pot is continuously immersed in oil. In the operation of the device, the spring 47, acting upon the head 46 of the dash pot plunger, tends to pull the plunger outwardly, thereby acting through the link 41 which is connected to the extension 40 of the pawl to swing the pawl toward the hub 28 of the table, so that it will be held against the hub and in position to engage the rear ends of the blocks 34, as illustrated in Fig. 2, so that when the ring is rotated in a clockwise direction, Fig. 2, the table and its hub will be rotated in such direction by the engagement of the pawl with the end of a block.

When the actuating ring 35 is rotated in the opposite or counter-clockwise direction, the pawl, which is angularly bent, will ride up upon the block until it drops off of the rear end of the block. In order to prevent the pawl from thus dropping off the block and being forced into normal position by the action of the spring 47 from impinging with such force against the hub as to be likely to injure the pawl, the rear ends of the block are slightly beveled or curved.

In order further to insure that the end of the pawl will not strike with undesirable force against the hub of the table, the dash pot plunger 42 is provided with a narrow groove 48 which will permit oil to enter the chamber of the dash pot when the plunger is drawn inwardly toward the ring as the pawl rides over the block, but which when the pawl is released by passing over the rear end of the block will check the flow of oil from the chamber as the piston is drawn into it by the spring 47 sufficiently to cause the end of the pawl gradually to come into engagement with the hub of the table.

The actuating ring 35 is oscillated from the fluid operated actuating mechanism. In the preferred construction the flange 36 of the ring 35 is pivotally connected by a link 49 to the forked end of an arm 50 which is built from two pieces connected together by suitable bolts 51, the opposite end of the arm 50 being keyed to the upper end of a vertical shaft 52. The shaft 52 is journalled in suitable bushings in a supporting bracket 53 which extends through an aperture in the top 30 of the table and is connected thereto by bolts 54. The bracket 53, (Fig. 3), serves to support the fluid operated motor and the mechanism operated thereby for actuating the shaft 52.

In the construction illustrated, the upper section 55 of a supporting casing for the actuating mechanism is secured to the bracket 53 by bolts 56 and the lower section 57 of the casing is secured to the upper casing by cone-shaped bolts 58 which pass through complementary flanges extending outwardly from the casing sections 55 and 56. The shaft 52 extends through both sections of the casing, the lower of which is provided with a suitable bushing for the lower portion of the shaft, and the lower end of the shaft 52 is provided with a cylindrical extension 59 of smaller diameter upon which a pinion 60 is mounted. The pinion 60 is secured to the shaft by lugs 61 which extend upwardly from the pinion hub into complementary recesses in the lower portion of the shaft 52. The opinion is retained upon the hub by a collar or washer 62 which is seated in an annular recess in the under face of the pinion and is clamped to the end of the extension 59 of the shaft by a machine bolt 63. The pinion 60 is engaged and actuated by a fluid operated rack for the purpose of rotating the shaft 52 in a reverse direction to restore the actuating ring to normal position as will hereinafter more fully appear.

The shaft 52 is rotated in a direction to advance the pawl for the purpose of rotating the table by a main fluid operated motor in the manner which will now be described.

The main fluid operated motor comprises a cylinder 64 which is provided with a closed end 65 of greater thickness than the wall of the cylinder and which is provided with an extension 66 of smaller diameter which extends into and is journalled in a trunnion block 67 provided with upper and lower trunnions 68 and 69 which are rotatably mounted in suitable bearings in the upper and lower sections 55 and 57 of the housing which is carried by the depending bracket 53. The cylinder is secured to the bearing block 67 by suitable machine bolts 70 which extend through the trunnion block 67 into the head 65 of the cylinder.

A piston 71 is reciprocably mounted in the cylinder 64 and is provided with a piston rod 72 which is reciprocably mounted in a bearing 73 having an enlarged head engaging the inner face of the cylinder head 65 and extending therethrough and held in place by a nut 74 which may be secured against rotation by a locking screw 75. The opposite end of the piston rod 72 has pinned, or otherwise secured to it, a connecting member 76 which is pivotally connected by links 77 and 78 respectively to the reduced end portions 79 and 80 of a stud 81 which is rotatably mounted in an arm 82 of a lever having a split hub 83 which fits upon the shaft 52 and is provided with extensions 84 and 85 which are clamped together by a machine bolt 86. The hub 83 desirably is also secured to the shaft by a key 87, (see Fig. 3).

The lever arm 82 is of irregular form and presents a flat surface 88 adapted to be engaged by a flat side of a square abutment member 89 having trunnions 90 pivotally mounted in the links 77 and 78. The engagement of the surface 88 with a surface of the abutment member 89 occurs when the parts are in normal position illustrated in Fig. 5, at which time the piston is in proximity to the head of the cylinder. When fluid under pressure is introduced into the cylinder, the engagement of the flat surface 88 with the abutment block 89 acts in effect to establish a rigid connection such that the arm 82, which is connected to the shaft 52, and the links 77 and 78, are rigid with each other when power is applied to the piston and act as an offset lever or bell crank to rotate the shaft

with the power applied by the piston rod directly to the outer end of the links 77 and 78, thereby producing a direct leverage upon the shaft which will rotate it until the end portions 79 and 80 and consequently the stud 81 are swung beyond a plane passing through the axis of the trunnion casing and the axis of the shaft 52. As the piston is forced outwardly away from the cylinder head, the arm 82 swings toward the position illustrated in Fig. 6, thereby removing the abutment 89 from engagement with the surface 88 so that after the arm has been swung beyond dead center the links 77 and 78 will act directly to swing the arm about the axis of the shaft 52 to the position illustrated in Fig. 6.

The rotation of the shaft 52 in the manner above described, therefore, causes a rotation of the arm 51 upon the upper end of the shaft in a clockwise direction, thereby acting through the link 49 to rotate the actuating ring 35 in a clockwise direction, thus causing the pawl, which is engaged with the block 34, to rotate the table and carry the work from one station to the next.

By reason of the fact that the cylinder 64 is supported upon the trunnions 68 and 69, the cylinder will rotate about the axes of its trunnions as the piston is forced outwardly, thereby maintaining the proper articulation between its end portion 76, the links 77 and 78, and the arm 82 of the lever which is connected to the shaft 52.

In order to introduce fluid under pressure into the cylinder, a conduit 91 is provided in the cylinder head which communicates with a corresponding L-shaped conduit 92 in the trunnion 69. Fluid under pressure is supplied to the conduit 92 from a pipe 93 which is connected to an L-shaped coupling 94 extending into one of the branches of the conduit 92 and secured to the wall thereof by a screw threaded connection.

By reason of this construction fluid is readily introduced into the cylinder irrespective of the position of rotation of the cylinder about the axes of its supporting trunnions.

Means for supplying fluid under pressure to the cylinder and for controlling the fluid pressure supply will hereinafter be described.

Preferably fluid operated means are provided for restoring the actuating ring 35 and the pawl carried thereby to normal position illustrated in Fig. 2 after the ring has been rotated to index the work-carrying table. In the construction disclosed herein an auxiliary fluid operated motor is employed having a piston provided with a rack which engages the gear 60 which, as above described, is fixedly secured to the lower end of the vertical shaft 52.

In the particular construction illustrated the auxiliary cylinder 95, (see Figs. 2, 5, and 6,) is formed integrally with an extension or pipe 96 of somewhat irregular form, as illustrated in dotted lines in Figs. 5 and 6, which engages the lower face of the lower section 57 of the casing which supports the main power cylinder and encloses the power transmitting mechanism operated thereby. The cylinder plate is secured to the lower section 57 of the casing by bolts 97 extending through flanges upon the cylinder and through suitable apertures in the extension plate into the lower wall of the casing 57.

The cylinder head 98, which is bolted to the outer end of the cylinder 95, is provided with a central boss 99 having an axial aperture therethrough which receives the end of a pipe 100 through which fluid is supplied to the cylinder. The piston 101, desirably is of tubular form providing a recess which will permit the full reciprocation of the piston without engaging the boss 99 upon the cylinder head. The piston rod 102 is provided with a toothed portion 103 forming a rack which engages the gear 60.

The means for supplying fluid under pressure through the pipe 100 to the cylinder 95 and the mechanism for controlling the supply of fluid in such manner as to actuate the auxiliary piston in properly timed relation to the actuation of the piston 71 of the main cylinder will hereinafter be described, it being sufficient for the present purpose to state that the actuation of the auxiliary piston occurs only after the piston of the main cylinder has been actuated to rotate the shaft 52 in a direction to index the table, the piston of the auxiliary cylinder being actuated subsequently to restore the actuating ring 35 to normal position and to return the piston of the main cylinder to normal position, as illustrated in Fig. 5.

The table arresting mechanism

Inasmuch as the table, the work supports, and the work carried thereby, are of great weight and acquire a very considerable momentum during the indexing operation, means are provided for exerting sufficient power yieldably to arrest the table in properly indexed positions. The mechanism employed in the present construction for this purpose is somewhat similar to that disclosed in my prior applications, but is of simplified construction.

The preferred mechanism, which is illustrated herein, comprises a stop member or latch 104 which is slidably movable into the path of the blocks 34 and when engaged thereby is capable of pivotal movement. The latch 104 is provided with a shank which is located between the top 30 of the base and an offset member 105 of a bracket 106 which is secured to the top 30 of the base. The shank of the latch 104 has a longitudinally extending slot 107 which engages a block 108 which is pivotally mounted upon a screw threaded stud 109 which passes through the extension 105 of the bracket and block 108 and is screwed into the top 30 of the base, so that the latch 104 is capable of a pivotal and bodily reciprocating movement. The block 108 also serves to limit the extent of movement of the latch in either direction by engagement with the respective end walls of the slot.

Links 110, which are pivotally connected at one end to the latch 104, are pivotally connected at their opposite ends to the piston rod 111 which desirably is integral with the piston 112 which is reciprocably mounted in a cylinder 113 of a dash pot 114 which is secured by bolts 115 to the top 30 of the base 1. The piston 112 has a section 116 of smaller diameter which is reciprocably mounted in a relatively long bearing 117 in the dash pot 114 and has a screw threaded extension 118 upon which a block 119 is mounted and secured against rotation thereupon by a pin 120 extending through the block and extension 118 of the piston.

The block 119 desirably is provided with a vertical recess having undercut walls to receive a hardened abutment member 121 which may be releasably secured in the recess by a set screw (not shown) or in any suitable manner. The abutment 121 is adapted to engage a valve-

actuating member, hereinafter to be described, and by providing abutments of different thicknesses the extent of movement of the valve may be readily and accurately determined.

Fluid under pressure is supplied to the cylinder 113 through a pipe 122 which communicates with an L-shaped conduit 123 in the block 114, and which in turn communicates with a conduit 124 of smaller diameter leading to a recess 125 in the under face of the piston extension 116.

The recess 125 in the piston is inclined so that when the piston is in normal position, illustrated in Fig. 11, fluid under pressure passes through the conduits 123 and 124 and the recess 125 into the cylinder 113. Fluid under pressure thus introduced will force the piston 112 to the right, Figs. 11 and 2, thereby swinging the latch 104 to the position shown in Fig. 2, from which position it is moved into the path of the blocks 34 by means hereinafter described.

During the rotation of the table one of the blocks 34 engages the latch 104 and forces it laterally to the left, Fig. 4, thereby forcing the piston 112 inwardly, and forcing fluid under pressure from the cylinder 113 through the recess 125 and conduits 124 and 123 against the fluid pressure supplied by the pipe 122, thus exerting a powerful but yieldable force upon the latch to arrest the movement of the table. The recess 125 in the section 116 of the piston, however, terminates short of its inner end, so that when the piston is moved sufficiently the cylindrical end portion 126 of the section 116 will close the port formed by the recess 125, thereby trapping the incompressible fluid in the cylinder, thereby effectively arresting the rotation of the table at a predetermined indexed position.

In order to restore the stop or latch 104 to normal position, means are provided for moving the latch first longitudinally out of engagement with the abutment 34, and thereafter for swinging the latch about its pivot, to the right, from the position shown in Fig. 4 to the position illustrated in Fig. 2. To accomplish this purpose a triangular link 127 is pivotally connected by a bolt 128 to a boss upon the latch 104, and is also pivotally fulcrumed upon a bolt 129 mounted in the free end of a link 130, the opposite end of which is pivotally mounted upon a bolt 131 extending through a bracket or keeper 132 into the top 30 of the base, the keeper 132 being also bolted to the base. The triangular link 127 is also pivotally connected by a bolt 133 to links 134, the opposite ends of which are pivotally connected by a bolt 135 to a piston rod 136 which preferably is integral with a hollow piston 137 which is reciprocably mounted in a cylinder block 138. The opposite end of the cylinder block is provided with an enlarged counterbore forming the piston chamber proper 139, and the piston is provided with an enlarged portion 140 which fits the cylinder 139. The wall of the cylinder 139 is provided with an annular recess 141 into which fluid under pressure is introduced constantly through a port 142. The fluid under pressure thus introduced into the cylinder acts upon the relatively narrow annular area of the head 140 of the piston between the body of the portion 137 and the enlarged head 140.

Fluid under pressure is also intermittently introduced into the chamber 139 of the cylinder through a port or pipe 143. The fluid under pressure is introduced through the pipe 143 at the time the locking devices for the carrier are actuated to lock the table against rotation.

The operation of the arresting mechanism may be described as follows. When the table is rotated by the mechanism heretofore described, one of the blocks 34 will engage the latch 104, which is then positioned in its path, and will force the same to the left, as illustrated in Fig. 4, thereby acting through the link 110 to force the piston 112 inwardly against the resistance of the fluid pressure supplied through the pipe 122 until the section 125 of the smaller piston section 116 closes the port 124 through which such fluid under pressure is supplied to the cylinder, thereby exerting a yielding powerful force to arrest the movement of the table. When, however, the port 124 is closed by the cylindrical portion 126 of the piston section 116, further movement of the table will be arrested by the incompressible fluid which is trapped between the piston 112 and the end of its cylinder, except for such slight amount as may leak around the piston.

At the same time movement of the latch 104, Fig. 4, to the left, will carry the link 127 to the left, thereby pulling upon the links 134 and the piston 137. Such movement of the piston, however, will be resisted by the constant fluid under pressure which enters through the pipe or port 142 into the portion of the cylinder in advance of the enlarged head 140 thereof, thus further aiding in the gradual checking of the rotation of the table.

After the table has been arrested, pressure is supplied to the diaphragm mechanism for locking the table in position and at such time pressure is introduced from the diaphragm system, hereinafter to be described, through the port 143 into the main chamber 139 of the piston, thereupon forcing the piston further to the left, Fig. 4, against the constant pressure supplied through the pipe 142 to the relatively narrow area of the piston head, thereby rocking the triangular link 127 about its pivot 129, thus withdrawing the latch 104 from engagement with the block 34, and permitting the latch 104 to assume the position illustrated in Fig. 2.

When pressure, which is supplied through the pipe 143, is again released, the constant pressure of the fluid supplied through the pipe 142 acting upon the opposite side of the enlarged piston head 140 will swing the link 127 in the opposite direction, thereby sliding the latch 104 endwise until the lower end wall of the slot 107 abuts against the block 34. The latch will then be held by said fluid pressure in position to be engaged by the next block upon the succeeding indexing movement of the table.

The controlling mechanism for supplying fluid under pressure to the parts of the locking mechanism in proper sequence may be and desirably is similar in operation to the controlling mechanism disclosed in my prior applications Serial Number 441,387 and 471,234, above mentioned.

The fluid operated controlling mechanism

The fluid operated controlling mechanism disclosed in my prior applications aforesaid comprised essentially (1) automatically operable means for preventing the operation of the means for actuating the rotating table unless and until all of the tools have been moved to a predetermined distance from the work; (2) fluid controlled means for preventing the actuation of the

means for locking the rotating table unless the work is approximately positioned properly at the several stations; (3) fluid operated means for preventing the actuation of the tool feeding means unless and until the work is properly positioned at the tool stations and locked in such position; (4) means for delaying the actuation of the tool-feeding means until locking of the work carrier is completed.

The mechanisms for accomplishing these functions which are disclosed in my prior applications comprise a source of fluid under pressure and interrelated controlling units in the piping system leading from the source of fluid under pressure to the table-locking mechanism and the mechanism for controlling respectively the actuation of the rotating table, the locking and unlocking of the table, and the actuation and arrest of the tool-feeding mechanism. Many of the same units are employed in the same construction and in the same relation in the present invention, and inasmuch as they are described in detail in the prior applications aforesaid, need not be illustrated and described in detail in this application, as their function will be apparent from the following description.

The units, which are common to the present construction and to the constructions disclosed in my prior applications, comprise the following:

Unit "A"—Main control valve,
Unit "B"—By-pass control valve,
Unit "C"—Table feeler release,
Unit "D"—Main pressure cut off valve,
Unit "E"—Main admission valve,
Unit "F"—Distributor valve,
Unit "G"—Retarder for the tool feeding mechanism,
Unit "H"—Automatic safety valve,
Unit "J"—Manual safety switch.

My prior application also comprised unit "I" retarder for table drive control, the equivalent of which, but not in the same form, is employed in the present invention, and unit "K" fluid control for the table arresting mechanism, an equivalent of which in a different form is embodied in the present application.

In my prior applications the table is actuated by an electric motor, while in the present invention the actuation of the table is performed by fluid operated motors. Consequently a new controlling unit for the fluid operated motors, which will be referred to as unit "L", is disclosed herein, and will be described in connection with the modified constructions of unit "I" and unit "K" which in certain respects control the operation of the new controlling unit "L".

In order to define the construction and operation of the new unit "L" and the modified units "I" and "K", the operation of the controlling system, in-so-far as it comprises the same units used in previous constructions will first be described.

In the present construction, as that previously described, the fluid under pressure is supplied by a pump 144 driven by any suitable source of power, such as an electric motor 145, and draws oil, or other suitable fluid, from the chamber within the base 1 of the machine, the base 1 preferably being sufficiently filled with oil to submerge the various units which are located within it.

The pump delivers fluid under pressure to an air chamber 146, for maintaining uniform fluid pressure, and from which it is conducted through a pipe 147 to unit "A", the main control valve, which when in normal position, with the table locked and the tools in operation, is so positioned as to deliver fluid under pressure through the pipe 148 to unit "B", by-pass valve, thereby so positioning the by-pass valve that upon actuation of the main valve, unit "A", fluid under pressure will be properly transmitted through the system of piping to arrest the tool-feeding means to release the tool-locking means and to initiate the action of the table-rotating means.

In the present construction illustrated in Fig. 1, one of the tool-actuating cams 15, which engages the roller 14 on the tool slide, is provided with a pin 149 adapted, when the tool is raised to a predetermined height, to engage a lever 150 which actuates the main control valve unit "A". In Fig. 1 the cam 15 is shown in the position which it occupies when the tools are being raised from the work and have closely approached the upper limit of their movement, so that by a slight further rotation of the cam 15 the valve 150 will be actuated.

While the valve "A" is in normal position illustrated in Fig. 1, fluid under pressure is also supplied from the storage tank or the pipe leading thereto from the motor through a pipe 151 through the main admission valve unit "E", and pipe 152 to the distributor unit "F", from which it passes through the several pipes 153 to the chamber of the fluid-actuated work-positioning and locking devices 4, thereby establishing pressure in the locking devices 4 and securely locking the table, and also the work sectors, accurately in position to present the work properly at the several tool stations. Fluid under pressure is also supplied through one of the pipes 153 through the retarder unit "G", to a pipe 154, which leads to the brake-releasing mechanism for the shaft of the tool-actuating motor 25. A branch pipe 155, leads from the pipe 154 to the fluid-actuated switch control 156 which operates a switch 157 in the circuit which supplies electric current to the tool-feeding motor 25. The switch 157 may be in the circuit of any suitable electric power transmission line.

The mechanism for supplying an electric current to the tool-feeding motor 25 illustrated herein is identical with that disclosed in my prior application Serial Number 471,234, in which conductors 158 and 159 of a power circuit lead to a magnetic switch 160 from which conductors 161 and 162 supply the electric current to the tool-feeding motor 25.

The magnetic switch 160 is controlled by a supplemental circuit comprising a generator 163 from which a conductor 164 leads through the switch 157 to the magnetic switch, while another conductor 165 from said generator also leads directly to the magnetic switch 160. The fluid-actuated switch control 156 is so connected to the switch 157 that when fluid pressure is established in the pipe 155 the switch will be thrown to, and maintained in, closed position as illustrated, thereby completing the supplemental circuit and causing the magnetic switch 160 to transmit current from the power line to the motor 25, thus causing the actuation of the tool-feeding mechanism.

The positions of the various parts of the mechanism are illustrated in detail herein, with the exception of Fig. 6, in normal position, that is with the table locked and the tools in operating position.

When the tools are raised by the tool-feeding

mechanism to the upper limit of their movement, the cam 15, which is provided with the pin 49, will have rotated slightly further in a counter-clockwise direction, thereby raising the lever 150, thus depressing the valve of the main control valve unit "A". The depression of this valve will shift fluid under pressure supplied through the pipe 147 to the pipe 166, and at the same time will establish communication between the pipe 148 and an exhaust pipe 167 which will relieve the pressure in the chamber of the by-pass valve unit "B", but which will not at this time shift the valve from the position in which it has been set by the pressure previously supplied through the pipe 148, as will more fully appear from the disclosure of my prior applications.

When fluid under pressure is supplied through the pipe 166, it will pass through the by-pass valve unit "B" to the table feeler release unit "C", thereby actuating a piston rod 168, to the left, to rock a bell crank lever 169, one arm of which is connected indirectly to the table feeler 170, thereby withdrawing the feeler from engagement with the table. At the same time the rocking of the bell crank 169 will actuate the main pressure cut-off valve unit "D", thereby closing the port through which pressure is supplied to said valve through a pipe 171 from the main admission valve unit "E". This movement of the main pressure cut-off valve unit "D", also opens an exhaust port which communicates with a pipe 172 which controls the main admission valve unit "E", and which also controls through a branch pipe 173 the valve of the distributor unit "F".

The release of fluid under pressure, therefore, from the pipe 172 relieves the pressure in the chamber of the main admission valve unit "E", thereby permitting its valve spring to force the main admission valve to the right, thus cutting off the supply of fluid under pressure through the pipe 152 to the distributor unit "F", and from the distributor to the locking device.

At the same time the release of pressure in the pipe 172 releases the pressure in the branch pipe 173, thereby permitting the valve of the distributor to open to exhaust position, so that the fluid under pressure will be released in all of the lines 153 which lead to the various table locking devices 4 and other mechanism to which pressure is supplied.

By reason, therefore, of the control above described the table will be unlocked and ready for indexing movement.

At the same time pressure is released in the pipe 153 which leads from the distributor to unit "G", so that pressure will be gradually released through the retarder from the pipe 154 which leads from the retarder to the brake-releasing mechanism of the tool-feeding motor 25, and also which maintains closed the switch 157 of the controlling circuit for the tool-actuating motor 25, thereupon breaking the circuit and arresting the motor 25 of the tool-feeding mechanism. At the same time the release of fluid under pressure in the pipe 153 and retarder unit "G" releases the fluid under pressure in the pipe 143 which leads to the cylinder 139 of the latch-restoring device, (see Fig. 4).

It has been stated that constant pressure is supplied through the pipe 142 to the cylinder 139 upon the opposite side of the piston. Such pressure is supplied to the pipe 142 from an extension of the main supply pipe 151. When, therefore, fluid under pressure is released from the pipe 143 and the main chamber at the end of the cylinder 139, the constant pressure of the fluid will force the piston 137 inwardly, thereby rocking the triangular bell crank link 127 to the right, thus moving the latch 104 longitudinally and causing it to rest upon the block 34 until during the rotation of the table further movement of the piston 137 will cause the end of the stop or latch 104 to engage the block 108 of the table as above described. As the latch 104 is thus moved to the right, (Fig. 2), the piston 112 of the dash pot cylinder 113 is moved slightly to the right, so that fluid under pressure is introduced into the cylinder 113 through the constant pressure pipe 122 which communicates directly with the main pressure pipe 151. The pressure thus introduced through the pipe 122 into the cylinder 113 will also aid in forcing the latch to the right and to the position in which it will engage the next succeeding block 34 upon the hub of the table.

By reason of the operation of the controlling devices above described, therefore, the table is unlocked and ready for indexing. The tool-feeding motor has been arrested and the table-arresting mechanism restored to operative position ready yieldably to stop the table at the end of the next indexing movement.

Electrically controlled safety mechanisms, similar to that disclosed in my prior applications aforesaid, are employed for preventing actuation of the table-rotating mechanism until all of the tools have been properly withdrawn from the work and all raised to a predetermined height. Furthermore, the completion of the safety electric circuit requires the manual controlling of a switch unit "J".

The safety circuit mechanism comprises a suitable source of electricity, such as a battery or generator 174 having a conductor 175 leading to the first of a series of switches, which are carried by supporting brackets 10 for the tool slides, each of which has a contact member 176 and a complementary contact member 177 adapted to be forced by arms 178 upon the respective tool slides into engagement with the switch members 176. A conductor 179 leads from the last switch member to a contact member 180 mounted upon an insulated support carried by bracket arms 181 of the manual safety switch unit "J".

The contact member 180 is adapted to be engaged by a contact member 182 upon a swinging arm 183 pivotally mounted upon the bracket arms 181. The contact member 182 is connected to a return conductor 184 which leads through a solenoid 185 to the battery or generator 174.

The bracket arms 181 of the manually operable switch are integral with a body member 186, which may be supported upon any convenient part of the machine, and which is provided with a cylindrical chamber 187 having a piston 188 reciprocably mounted therein. The piston 188 is provided with a section 189 of reduced diameter and with an extension 190 therefrom which is adapted to be projected beyond the end of the body 186. A spring 191, which is interposed between the piston 188 and the end of the cylinder 187, normally tends to withdraw the extension 190 into the casing. Fluid under pressure is supplied to the cylinder from one of the pipes 153 which lead to the table-locking member 4, so that when fluid under pressure is supplied to the table-locking means the extension

190 will be thrust outwardly. A bolt 192 is slidably mounted in the swinging arm 183 which is L-shaped and is adapted to be projected from the elbow thereof into the path of the piston extension 190 by a spring 193.

A handle 194, which is pivotally mounted in the offset end of the L-shaped arm, is provided with an arm 195 adapted to engage the bolt 192 when the handle 194 is swung to the right, thereby withdrawing the bolt 192 sufficiently to permit it to be swung over the extension 190, as illustrated in Fig. 13, to close the circuit.

When, therefore, pressure is released in the cylinder 187 the spring 191 will force the piston inwardly, thereby withdrawing the extension 190 from beneath the bolt 192, so that the latter will be extended into the path of the extension. When pressure is supplied upon the locking of the table through the pipe 153, the piston will be moved by fluid pressure in the opposite direction against the tension of the spring 191, thereby causing the extension 190 thereof to engage the bolt 192 and swing the arm 183 about its pivot, thus breaking the circuit. The operator may, however, complete the circuit at any time after he has placed the work upon the work table by swinging the handle 194 to the right, so as to raise the bolt 192 above the extension, and upon further movement thereof completing the contact between the switch members 180 and 182, as illustrated in Fig. 13. This switch may be completed either before or after the tools have reached the upper limit of their position, but all the tools must have reached such upper limit before the safety circuit will be completed.

Upon the completion of the safety circuit the solenoid 185 will be energized. The energization of this solenoid is utilized to actuate an automatic safety valve unit "H" which corresponds to a similar safety valve in my prior applications above referred to, but is differently located. The unit "H" in the present construction may be and desirably is located within the chamber of the base of the machine and is submerged in oil. This unit comprises a cylindrical casing 196 having a valve 197 reciprocable therein. The valve 197 is provided with an enlarged head 198 adapted to abut against one end of the casing and is also provided with an extension 199 which forms or is connected to the core of the solenoid. The valve 197 is provided at its opposite end with a reduced section 200 having an extension 201 of smaller diameter upon which an abutment plate 202 is secured by a suitable nut upon the screw threaded portion of the extension 201. A coiled spring 203, seated in a countersink in the casing and engaging at its opposite end against the abutment 202, tends to draw the valve 197 to the left, as indicated in Fig. 12, thus causing the abutment 198 to engage the opposite end of the casing. The valve 197 is provided centrally with a reduced portion 204 forming a port to which fluid under pressure is supplied through a pipe 205 leading from the main pressure pipe 151.

The pipe 206, which is also positioned to communicate with the valve port 204, conducts fluid under pressure to valve mechanism for controlling the supply of fluid under pressure to the fluid operated motor for rotating the table. This unit will be referred to herein as table actuating motor control unit "L". The port 204 of the automatic safety valve unit "H" is also adapted to communicate with a pipe 207 which communicates with one of the pipes 153 which supply fluid from the distributor unit "F" to the several table-locking devices. There is, however, interposed in the pipe 207 a retarding device which is illustrated in detail in Fig. 10. As shown in this construction the pipe 207 is formed in two alined, narrowly separated, sections having screw threaded adjacent ends. Collars 208 and 209 are screwed upon the end portions of the pipe and clamp between them a plate 210 having a small aperture therethrough preferably in axial alinement with the pipe sections 207. These collars may be secured together by clamping bolts 211.

By reason of this construction flow of fluid through the pipe 207 is gradually restricted and its passage therethrough delayed for purposes which will hereinafter appear.

The pipe 207 also communicates with a retarding device, which will be referred to as unit "I" retarder for table drive control. The retarder unit "I" comprises a cylindrical casing 212 having a cylindrical chamber 213 which is connected through a T 214 with the pipe 207. A hollow piston 215 is reciprocably mounted in the chamber 213 with its closed end toward the pipe 214. The opposite end of the chamber 213 is closed by a head 216 which is secured to the casing and which is provided with a cylindrical extension 217 extending into the chamber of the piston 215. A piston 218 is reciprocably mounted in the cylindrical extension 217. The head 216 is also provided with an outwardly projecting extension 219 having therein a cylindrical chamber 220 which preferably is of somewhat larger bore than the chamber in which the piston 218 is reciprocably mounted.

The extension 219 is closed by a screw threaded plug 221 having a central passage therethrough through which a pipe 222 communicates with the chamber 220. The opposite end of the pipe 222 communicates with the main fluid pressure pipe 151. A suitable vent port 223 leads through the head from the space between the extension 217 of the head and the piston 215 which reciprocates in the cylindrical chamber 213.

During the normal operation of the machine, when the table is at rest and the tool-feeding mechanism is in operation, fluid under pressure will be supplied through the pipe 151, its branch 205, through the valve port 204, to the pipe 206 in such manner as to position the valve of the table-actuating motor control in position to cut off supply of fluid under pressure to the fluid operated motor. When, however, the safety circuit is complete, the solenoid 185 will be energized, thereby drawing the valve 197 to the left, thereby cutting off the supply of fluid under pressure through the branch pipe 205 and establishing communication between the pipe 206 and the pipe 207. The fluid passing through the pipe 207 will be restricted by the minute passage through the plate 210 of the retarding device and will enter the chamber 213 of the retarder, thereby acting upon the end of the piston 215. As the area of the piston end is very much greater than the area of the smaller piston 218, which is acted upon by constant pressure supplied through the pipe 222, the piston 215 will be forced to the position illustrated in Fig. 10. When, however, pressure is relieved in the pipe 207, the piston 218 will be forced to the left by the fluid pressure in the chamber 220, thereby forcing a very considerable amount of fluid through the T 214 into the pipe 207, and thence through the port 204 of the automatic safety valve to the

pipe 206 which controls the actuation of the table-actuating motor control unit "L", thereby maintaining the supply of fluid under pressure required to hold the valve of unit "L" in exhaust position until the completion of the unlocking of the table and the arrest of the tool-feeding mechanism is insured.

The table actuating motor control unit "L"

The table actuating motor control unit "L" is illustrated in Figs. 7, 8, and 9, of the drawings, and comprises a preferably rectangular block or casing 224 having a longitudinally extending cylindrical chamber 225 in which a cylindrical valve 226 is reciprocably mounted and provided with an annular port 227. The ends of the valve 226 desirably are chambered and a coiled spring 228 is interposed between the base of the chamber at one end of the valve and a head 229 having a central aperture which receives the end of the pipe 206 leading from the automatic safety valve unit "H".

The upper wall of the valve casing is provided with a series of exhaust ports 230 leading to the valve chamber 225 and adapted to communicate with the chamber 227, as illustrated in Fig. 8, and is also provided with a similar series of inlet ports 231 adapted to communicate with the valve chamber 227 when the valve is moved against the action of the spring 228 in position to close the ports 230. The valve casing 224 has secured to it a cap 232 having wide chambers 233 and 234 communicating respectively with the ports 230 and 231. The chamber 233 communicates with an exhaust pipe 235 adapted to discharge the fluid into the base of the machine. The chamber 234 communicates with a pipe 236 which leads from the main pressure supply pipe 151.

The chamber 234 communicates through a vertical bore 237 with a cross bore 238 in the lower portion of the casing which in turn communicates through a longitudinally extending passage 239 with a passage 240 in a head 241 which is secured to the block 224 by bolts 242. The head 241 is provided with a bore in axial alinement with the piston forming a chamber 243 and the vertical bore 240 establishes communication between the bore 239 and the chamber 243 in the head. A piston 245, which is reciprocably mounted in the chamber 243, engages the end of the valve 226 opposite to that which is acted upon by the spring 228.

The annular port 227 also communicates with a large port 246 from which the pipe 93 leads to the conduit in the trunnion 69 of the table-actuating motor, and fluid supplied therethrough will enter the chamber of the cylinder 64 to force the piston outwardly from the position shown in Figs. 3 and 5 to that illustrated in Fig. 6 when the valve 226 is so positioned that the chamber 227 communicates with the inlet chamber 234 through which pressure is supplied from the main pressure line 236.

The piston valve of the table-actuating motor control is illustrated in Fig. 8 in the position which it assumes when the table is locked and the tools are in operation. At this time the pressure supplied through the main supply pipe 151 and pipe 153 to unit "J" has forced its piston in a direction to swing the switch arm 183 outwardly, thereby breaking the electric circuit and deenergizing the solenoid, so that the spring 203 of the automatic safety valve, unit "H", will be forced to the left, to the position illustrated in Fig. 12, thereby establishing communication between the pipe 205 through which fluid under pressure is supplied from the main supply pipe 151. Fluid under pressure will then pass from the pipe 205 through the valve port 204 and pipe 206 to the chamber 225 of the control valve unit "L", thereby holding the valve in exhaust position and relieving the piston 71 of the table-rotating cylinder 64 of pressure.

This is the position which is assumed by the valve 226, unit "L", during the normal operation of the machine when the tools are reciprocated to and from the work. During this time the operator removes the finished work at the loading tool station and positions and clamps a new work piece upon the work support.

When the new piece is thus secured upon the work table he may actuate the handle 194 of the manual safety switch, unit "J", to complete the circuit, as illustrated in Fig. 13, so that when all of the tools have been raised to a predetermined height and the switch members 177 caused to engage the complementary switch members 176, the safety circuit will be completed and the solenoid 185 energized. The energization of the solenoid 185 will move the valve 197 of the automatic safety valve, unit "H", to the right, Fig. 12, thereby cutting off the supply of fluid under pressure from the main pipe and branch 205 through the valve port 204 to the pipe 206. When thus positioned the port 204 will establish communication between the pipes 206 and the pipe 207 which communicates through the narrow orifice in the plate 210, (Fig. 10) with one of the pipes leading from the distributor unit "F" to a fluid-operated carrier-locking member 4, the fluid under pressure in the pipe 207 being at this time under the influence of the retarder unit "I" above described, so that the release of pressure from the chamber 225 of the table-actuating motor control unit "L" will be delayed after the pin 149 upon the tool-actuating cam 14 has shifted the main control valve to cut off communication between the main supply pipe 147 and the pipe 148 which positions the by-pass control and to establish communication between the main supply pipe 147 and the pipe 166.

This causes fluid under pressure to operate the table feeler release unit "C", thereby withdrawing the feeler from engagement with the table and cutting off the supply of fluid under pressure through the pipe 172 to the main admission valve unit "E" and establishing communication between the pipe 172 and the exhaust of the main pressure cut-off, as disclosed in my prior applications aforesaid.

When pressure in the pipe 172 is thus released, the main admission valve, unit "E", will be restored to inoperative position in the manner described in my earlier applications, so that fluid under pressure will no longer pass through the pipe 152 to unit "F". At the same time the release of pressure in pipe 172 will relieve the pressure in pipe 173 permitting the valve of the distributor unit "F" to exhaust, thereby relieving pressure in the pipes 153 leading to the table-locking mechanism. Thus the feeler is removed from engagement with the table and the table is unlocked and ready for indexing.

When fluid under pressure is released from the pipes 153, pressure is gradually released from the chamber 225 of the table-actuating motor control unit "L" as above described, so that fluid pressure upon the piston 245, which is

supplied through the pipes 236, the passage 237, the bores 238, 239, 240, and 243, will force the piston 226 of unit "L" to the right, Fig. 8, thereby establishing direct communication through the pipe 236 and the ports 231 and valve port 227 with the port 246 and pipe 93 which leads to the main power cylinder.

When fluid under pressure is thus introduced into the main power cylinder 64, the piston 71 is moved outwardly, Fig. 3, and thereby acts through the links above described to rotate the table-actuating ring 35, thereby causing the pawl 38 to engage one of the blocks 34 and rotate the table one step of its indexing movement. During this rotation of the table, an arm 247, which is secured to a shaft 248, (see Fig. 2) and is braced against one of the blocks 34 by a spring 249, rides off of the block, thereby causing the shaft 248 to rotate. This shaft 248 extends downwardly through the top 30 of the base and is provided with an arm which, as the arm 247 slides off of the block 224, engages the piston of the by-pass valve, unit "B", forcing the same inwardly, thereby releasing the fluid pressure upon unit "B", so that the feeler is forced upwardly by the spring of unit "D" into engagement with the table, and is ready to enter the next socket in the table when the table reaches a proper indexing position.

As the table approaches the end of an indexing movement, one of the blocks 34 engages the latch or stop 104 (Fig. 4) and forces it to the left, as above described, thereby forcing the piston 112 of the dash pot 113 inwardly and forcing fluid under pressure from the chamber of the dash pot through the recess 125 and passage 124 against the constant pressure in the passage 122, thus gradually checking the movement of the table. After the piston 112 has moved a sufficient distance, the cylindrical section 126 of the piston extension 116 will close the passage 124 and the piston will then be positively arrested by the incompressible fluid trapped in the chamber of the dash pot 113. As the piston 112 approaches the limit of its movement, the abutment 121, (see Fig. 11) engages the head 250 of the valve of the fluid control for the table arresting mechanism unit "K". This fluid control for the table arresting mechanism comprises a casing 251 having a downwardly extending boss 252 which is seated in a suitable aperture in the top 30 of the base, and is secured to the base in any suitable manner. A cylindrical valve 253 is reciprocably mounted in the casing. Its movement in one direction is limited by a head 254 and in the opposite direction by a chambered head 255 which is screwed into the casing 251.

The cylindrical valve 253 is provided with a chamber 256 which has a central recess 257 communicating with ports 258 which lead to an annular recess 259 in the periphery of the cylindrical valve. The recess 259 communicates with a pipe 260, (see Fig. 1) which communicates with the pipe 207 leading from unit "H".

An extension of the main fluid pressure supply pipe 151 communicates through a port 261 with the chamber 256 of the piston. A supplemental annular valve 262, is normally held in engagement with the end wall of the chamber 256 of the cylindrical valve 253 by a spring 263 thereby preventing the flow of fluid from the pipe 151 through the recess 257 and ports 258 to the pipe 260. The stem 264 of the valve 262 carries the head 250 above described. When, therefore, at the end of the movement of the dash pot piston 112, the abutment 121 strikes the head 250 of the valve stem 264, the valve 262 will be forced away from its seat, thereby permitting fluid under pressure supplied through the pipe 151 to flow through the recess 257 and ports 258 to the pipe 260.

The fluid under pressure thus supplied to the pipe 260 passes into the pipe 207 and thence through the port 204 of the automatic safety valve which is then positioned by the energized solenoid through the pipe 206 into the chamber 225, (Fig. 8) of the table actuating motor control unit "L", thereby forcing the valve 226 thereof to exhaust position, thus relieving fluid pressure in the power cylinder 64 just before the completion of the indexing movement of the table.

When the table has reached a properly indexed position, the feeler 170 will enter a socket in the table in the manner described in my prior applications aforesaid, thereby permitting the restoration of the main pressure cut-off valve to the position in which fluid will be supplied from the main pressure supply pipe 151 through the pipe 171 and the valve of the main pressure cut-off valve unit "D" to the pipe 172, thereby forcing the main admission valve unit "E" to normal position, and at the same time by supplying pressure through the branch pipe 173 closing the valve of the distributor unit "F", so that fluid under pressure will be supplied through the pipe 152 to the distributor and from the distributor through the pipes 153 to the several locking devices, thus locking the table and properly positioning the work with respect to the tools.

At the same time the pressure in one of the pipes 153 will pass slowly through the retarder unit "G" to the pipe 154, thereby releasing the brake of the tool-feeding motor 25 and also flowing through the pipe 155 closing the controlling circuit for the table-actuating motor 25, thereby supplying current to the table-actuating motor 25 and causing the actuation of the tool-feeding mechanism.

When pressure is thus restored in the pipes 153 leading to the locking devices, fluid under pressure will be supplied through the pipe 100 to the auxiliary cylinder 95, (see Figs. 1, 5, and 6,) thereby forcing its piston inwardly and causing its rack 103 to rotate the gear 60 and the shaft 52 to which it is attached in a direction to rotate the table-actuating ring to normal position ready for the next indexing movement of the table.

The fluid-operated motor for rotating the table may be made of such size and capacity and may be supplied with fluid under such pressure that positive rotation of the table is insured.

The mechanism for thus rotating the table from the fluid-operated motor is relatively simple and comprises rigid members which are not likely to wear out during the life of the machine. It may be housed within the hollow base of the casing and submerged in oil, or other actuating fluid, and therefore subject to continuous lubrication.

The use of such a motor for actuating the table eliminates the electric motor and the numerous parts required for the transmission of power therefrom to the hub of the table disclosed in my prior constructions and avoids the necessity of such overhead construction as was

required in mechanisms described in my prior applications.

The controlling mechanisms for the fluid-operated motor are relatively simple and necessarily function in proper timing with the other mechanisms of the machine.

While the present invention is illustrated herein as applied to a multiple spindle drilling machine having a rotating table, it will be obvious that the invention may be employed in other constructions and machines for other purposes than drilling and that, therefore, the specific embodiment of the invention disclosed herein is of an illustrative character and not restrictive of the meaning and scope of the following claims.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. A machine of the class described having a hollow base constituting an oil reservoir, a top therefor provided with an upwardly extending column or boss, a work carrier having a hub mounted upon said column or boss, and provided with pawl-engaging members, a pawl-actuating ring mounted upon said hub having a pawl engaging said boss, a support depending from said top into the chamber of said hollow casing, a rock shaft mounted in said support having an arm connected to said ring means for actuating said rock shaft including, a fluid-actuated motor pivotally mounted upon said depending support and having a piston and piston rod, means connecting said piston rod to said rock shaft operable by the movement of said piston rod to actuate said rock shaft and thereby to rotate said carrier, all contained within said base and adapted to be submerged in the oil in said reservoir, and means for supplying fluid to said fluid-actuated motor.

2. A machine of the class described having a hollow base constituting a liquid reservoir, a top therefor provided with an upwardly extending column or boss, a work carrier having a hub mounted upon said column or boss, and provided with pawl-engaging members, a pawl-actuating ring mounted upon said hub having a pawl engaging said boss, a support depending from said top into the chamber of said hollow casing, a rock shaft mounted in said support having an arm connected to said ring, a fluid-actuated motor pivotally mounted upon said support having a piston and piston rod, means connecting said piston rod to said rock shaft operable by the movement of said piston rod to actuate said rock shaft and thereby to rotate said carrier, an auxiliary motor mounted upon said support having a piston provided with a rack, a pinion on said rock shaft, and means for releasing pressure from said fluid-actuated motor, and means operable thereafter to supply fluid under pressure to said auxiliary motor to restore said rock shaft to normal position.

3. In a machine of the class described having a plurality of tool stations and a traveling work carrier, having feeler-engaging means, a fluid-operated motor and means operable thereby for indexing said carrier to present the work successively at said tool stations, fluid pressure operated means for locking said carrier with the work presented at said stations, fluid-actuated controlling mechanism including a main pressure cut-off valve operable to release the fluid pressure from said locking means, then to cause said motor to index said carrier, a feeler connected to said main cut-off valve operable upon engagement with the co-operating feeler-engaging means on the carrier to cause said main pressure cut-off valve to release the fluid under pressure from said motor, and then to restore fluid under pressure to said locking means.

4. In a machine of the class described having a plurality of tool stations and a travelling work carrier, having feeler-engaging means, a fluid-operated motor and means operable thereby for indexing said carrier to present the work successively at said tool stations, fluid pressure operated means for locking said carrier with the work presented at said stations, fluid-actuated controlling mechanism including a main pressure cut-off valve operable to release the fluid pressure from said locking means, then to cause said motor to index said carrier, a feeler connected to said main cut-off valve operable upon engagement with the co-operating feeler-engaging means on the carrier to cause said main pressure cut-off valve to release the fluid under pressure from said motor, and then to restore fluid under pressure to said locking means, and an auxiliary fluid-operated motor operable by the fluid under pressure acting upon said carrier-locking means to restore said indexing means to normal position.

5. In a machine of the class described having a plurality of tool stations and a travelling work carrier having a hub, means for indexing said travelling carrier to present the work successively at said tool stations comprising pawl-engaging means on said carrier, a pawl-actuating ring rotatably mounted on said hub having a pawl co-operating with said pawl-engaging means, a fluid-operated motor having a reciprocable piston and piston rod, means connecting said piston rod and said pawl actuating ring including a rock shaft having an upper arm, a link connecting said arm to said pawl-actuating ring, a lower arm on said rock shaft, a link connected at one end thereto and connected at its opposite end to said piston rod operable by said fluid-operated motor to move said pawl a sufficient distance to advance the carrier from one indexed position to the next, a gear on said rock shaft, and an auxiliary fluid-operated motor having a piston rod provided with a rack engaging said gear operable to rotate said rock shaft in a reverse direction and thereby restore said pawl and its actuating mechanism to normal position.

6. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, fluid-operated means for locking said carrier, means for supplying fluid under pressure, controlling means therefor operable selectively to supply fluid under pressure to said locking means, or to release said fluid under pressure therefrom, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure when supplied to said locking means to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means gradually to actuate said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier.

7. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, fluid-operated means for locking

said carrier, means for supplying fluid under pressure, controlling means therefor operable selectively to supply fluid under pressure to said locking means, or to release said fluid under pressure therefrom, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure when supplied to said locking means to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, and means for retarding the release of fluid pressure upon said motor-controlling valve operable to delay the action thereof until the completion of the locking of said carrier.

8. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop operable gradually to arrest said carrier, fluid-operated means for locking said carrier, means for supplying fluid under pressure, controlling means therefor operable selectively to supply fluid under pressure to said locking means or to release said fluid under pressure therefrom, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure when supplied to said locking means to retain said motor-controlling valve in exhaust position, and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, a valve operable by said yielding stop before the completion of the carrier-arresting movement thereof for supplying fluid under pressure to said motor-controlling valve to move said motor-controlling valve to exhaust position, whereby said motor will be rendered inoperative just before the completion of the indexing movement.

9. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop operable gradually to arrest said carrier, fluid-operated means for locking said carrier, means for supplying fluid under pressure, controlling means therefor operable selectively to supply fluid under pressure to said locking means or to release said fluid under pressure therefrom, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure when supplied to said locking means to retain said motor-controlling valve in exhaust position, and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, a valve operable by said yielding stop before the completion of the carrier-arresting movement thereof for supplying fluid under pressure to said motor-controlling valve to move said motor-controlling valve to exhaust position, whereby said motor will be rendered inoperative just before the completion of the indexing movement, a supplemental fluid-operated motor, and means operable by the fluid under pressure supplied to said locking means to restore the carrier-indexing means to normal position.

10. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing the carrier to present the work successively to said tool stations, tools at certain of said stations, fluid-operated means for locking said carrier with the work positioned at said stations, tool-feeding means, means including fluid-operated means for causing the actuation of said tool-feeding means, means for supplying fluid under pressure, means for conducting said fluid under pressure to the respective fluid-operated means, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure supplied to said locking means to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, a main controlling valve for said fluid under pressure selectively operable to control the supply of fluid under pressure to said locking means and to said tool-feeding means or to by-pass said fluid under pressure, and means operable by the by-passed fluid to release the fluid under pressure upon said locking means and said tool-feeding means, whereby upon release of pressure upon said locking means the control valve for said carrier-indexing motor will be actuated to supply fluid under pressure to said motor to index said carrier.

11. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing the carrier to present the work successively to said tool stations, tools at certain of said stations, fluid-operated means for locking said carrier with the work positioned at said stations, tool-feeding means, means including fluid-operated means for causing the actuation of said tool-feeding means, means for supplying fluid under pressure, means for conducting said fluid under pressure to the respective fluid-operated means, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure supplied to said locking means to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, a main controlling valve for said fluid under pressure selectively operable to control the supply of fluid under pressure to said locking means and to said tool-feeding means or to by-pass said fluid under pressure, means operable by the by-passed fluid to release the fluid under pressure upon said locking means and said tool-feeding means, whereby upon release of pressure upon said locking means the control valve for said carrier-indexing motor will be actuated to supply fluid under pressure to said motor to index said carrier, and means for retarding the release of fluid under pressure from the controlling valve for said carrier-indexing motor operable to delay the action thereof until the completion of the locking of said carrier.

12. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing the carrier to present the work successively to said tool stations, tools at certain of said stations, fluid-operated means for locking said carrier with the work positioned at said stations, tool-feeding means, means including fluid-operated

means for causing the actuation of said tool-feeding means, means for supplying fluid under pressure, means for conducting said fluid under pressure to the respective fluid-operated means, a controlling valve for said carrier-indexing motor, means operable by the fluid under pressure supplied to said locking means to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, a main controlling valve for said fluid under pressure selectively operable to control the supply of fluid under pressure to said locking means and to said tool-feeding means or to by-pass said fluid under pressure, means operable by the by-passed fluid to release the fluid under pressure upon said locking means and said tool-feeding means, whereby upon release of pressure upon said locking means the control valve for said carrier-indexing motor will be actuated to supply fluid under pressure to said motor to index said carrier, and an auxiliary fluid-actuated motor operable by fluid under pressure supplied to said carrier-locking means to restore the carrier-indexing means to normal position.

13. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop including a dash pot operable gradually to arrest said carrier and to position the work at said stations, fluid-operated means for locking the carrier when arrested, fluid-operated means for restoring said stop to operative positions, means for supplying fluid under pressure to said locking means, a main control valve selectively operable to control the supply of fluid under pressure to said locking means or to by-pass said fluid under pressure therefrom, means operable by the by-passed fluid under pressure to release the fluid under pressure from said locking means, a controlling valve for said carrier-indexing motor, means operable by fluid under pressure when supplied to said locking means by said main control valve to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier.

14. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop including a dash pot operable gradually to arrest said carrier and to position the work at said stations, fluid-operated means for locking the carrier when arrested, fluid-operated means for restoring said stop to operative positions, means for supplying fluid under pressure to said locking means, a main control valve selectively operable to control the supply of fluid under pressure to said locking means or to by-pass said fluid under pressure therefrom, means operable by the by-passed fluid under pressure to release the fluid under pressure from said locking means, a controlling valve for said carrier-indexing motor, means operable by fluid under pressure when supplied to said locking means by said main control valve to retain said motor-controlling valve in exhaust position and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier, and means operable by said dash pot just before the completion of its carrier-arresting movement to restore said motor-controlling valve to exhaust position.

15. In a machine of the class described having a plurality of tool stations and a travelling work carrier, means for actuating said carrier to present the work successively to said tool stations, a yieldable stop mechanism including a dash pot for gradually arresting the carrier to position the work at said tool stations, means for supplying fluid under pressure to said dash pot having means operable gradually to permit fluid under pressure to escape therefrom against the pressure of the fluid supplied thereto during the major portion of the carrier-arresting movement of the dash pot plunger and positively to cut off the release of fluid under pressure from said dash pot at the end of the indexing movement, thereby positively determining the extent of the indexing movement, fluid-operated means for locking the carrier in indexed position, and means operable by fluid under pressure when supplied to said carrier-locking means to restore said stop mechanism to normal position.

16. In a machine of the class described having a plurality of tool stations and a rotatable work-carrying table provided with a series of blocks corresponding to the respective tool stations, means for indexing said rotatable table to present the work successively at said tool stations, a stop adapted to be engaged by the respective blocks comprising a latch pivotally and slidably mounted to move into and out of the path of said blocks, a dash pot having a plunger flexibly connected to said latch, means for supplying fluid under pressure to said dash pot and to permit the fluid to be forced therefrom during the major portion of the table-arresting movement of the dash pot and to prevent escape of fluid under pressure therefrom at the end of the predetermined indexing movement, fluid-operated means for locking the rotatable table in indexed position, and means operable by the fluid under pressure supplied to said locking means to remove said latch from engagement with said block, and means operable by fluid under pressure upon release of fluid under pressure from said locking means to restore said latch to lock-engaging position.

17. In a machine of the class described having a plurality of tool stations and a rotatable work-carrying table provided with a series of blocks corresponding to the respective tool stations, means for indexing said rotatable table to present the work successively at said tool stations, a stop adapted to be engaged by the respective blocks comprising a latch pivotally and slidably mounted to move into and out of the path of said blocks, a dash pot having a plunger flexibly connected to said latch, means for supplying fluid under pressure to said dash pot and to permit the fluid to be forced therefrom during the major portion of the table-arresting movement of the dash pot and to prevent escape of fluid under pressure therefrom at the end of the predetermined indexing movement, fluid-operated means for locking the rotatable table in indexed position, a floating bell

crank lever pivotally connected to said latch, fluid-operated latch-restoring means connected to one arm of said bell crank lever operable by fluid under pressure when supplied to said locking means to withdraw said latch from engagement with the engaged block of the table, and means for supplying fluid under pressure to said latch-restoring means to position said latch for engagement with the next succeeding block.

18. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop operable gradually to arrest said carrier, fluid-operated means for locking said carrier, means for supplying fluid under pressure, a controlling valve for said carrier-indexing motor, means operable by fluid under pressure when supplied to said locking means to retain said motor-controlling valve in exhaust position, and operable upon release of fluid under pressure from said locking means to cause said motor-controlling valve to supply fluid under pressure to said motor and thereby cause the same to index said carrier.

19. In a machine of the class described having a plurality of tool stations and a travelling work carrier, a fluid-operated motor for indexing said carrier to present the work successively to said tool stations, a yieldable stop operable gradually to arrest said carrier, means for supplying fluid under pressure, a controlling valve for said carrier-indexing motor, a valve operable by said yieldable stop before the completion of the carrier-arresting movement for supplying fluid under pressure to said motor-controlling valve to move said motor-controlling valve to exhaust position, whereby said motor will be rendered inoperative just before completion of the indexing movement.

RALPH M. LOVEJOY.